

*In this activity, students will design a bridge or a building and observe how it performs in a simulated earthquake. Then, they will revise their designs to make them stronger and perform the simulation again.*

## OVERVIEW

**Topic: Engineering design and earthquakes**

### Real World Science Topics:

- An exploration of engineering design
- An exploration of the effects of earthquakes on structures

### Objective

Students will gain an understanding of how earthquakes can affect structures like bridges and buildings. They will also apply the principles of engineering design to construct, test, and modify structures in response to simulated earthquakes.

### Materials Needed for Student Activity

#### Materials Needed for Teacher Demonstration

- image of damage from earthquakes

#### Materials Needed for Student Teams

- wooden blocks
- tape
- popsicle sticks
- glue
- string
- freestanding table (or, alternatively, a large piece of cardboard)
- straws
- other suitable model-building material

### Teacher Notes

Use your discretion on the best way to conduct this activity based on the individual level of your class. For some of the younger K-1 classes, you may wish to perform some or all of the steps of the activity, encouraging children to make predictions and observations. If the group is older or more advanced in their abilities, students can take a more hands-on role in performing the related tasks. Leveled methodologies for K-1 and 2-3 grade levels are provided, where appropriate, throughout the activity. Use your knowledge of each class to determine what the best option is for your particular group.

### Teacher Preparation

You may wish to build two models, one reinforced and one not, prior to teaching this lesson.

## Standards Met

### NATIONAL SCIENCE STANDARDS ADDRESSED

#### CONTENT STANDARD A: Science as Inquiry

As a result of activities in grade K-4, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings of scientific inquiry

#### CONTENT STANDARD B: Physical Science

As a result of activities in grade K-4, all students should develop

- Understandings of the properties of objects and materials
- Understandings of the position and motion of objects

#### CONTENT STANDARD D: Earth and Space Science

As a result of activities in grade K-4, all students should develop

- Understandings of the properties of Earth materials
- Understandings of the changes in Earth and sky

#### CONTENT STANDARD E: Science and Technology

As a result of activities in grade K-4, all students should develop

- Abilities of technological design
- Understandings about science and technology

#### CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities in grade K-4, all students should develop

- Understandings of changes in environments
- Understandings of science and technology in local challenges

## NATIONAL MATH STANDARDS ADDRESSED

- Describe qualitative change, such as a student's growing taller
- Recognize, name, build, draw, compare, and sort two- and three-dimensional shapes
- Describe attributes and parts of two- and three-dimensional shapes
- Investigate and predict the results of putting together and taking apart two- and three-dimensional shapes
- Recognize geometric shapes and structures in the environment and specify their location

## NATIONAL TECHNOLOGY STANDARDS ADDRESSED

### CREATIVITY AND INNOVATION

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:

- Apply existing knowledge to generate new ideas, products, or processes
- Create original works as a means of personal or group expression
- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

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## Sources

### National Science Teachers Association

<http://books.nap.edu/html/nses/overview.html#content>

### National Council of Teachers of Mathematics

<http://standards.nctm.org/document>

### National Educational Technology Standards

<http://www.iste.org/standards/nets-for-students/nets-student-standards-2007.aspx>

# STEPS FOR *SHAKY GROUND*

- 1. Warm-Up Activity:** Introduce the activity by showing the class an image of damage caused by an earthquake. Tell them that the damage shown was caused by an earthquake. Ask students if they know about earthquakes, and allow them to share any knowledge they already have. Make sure students understand that during an earthquake, the ground shakes. Younger students do not need to understand the tectonic forces responsible for earthquakes or the different types of waves that can be present in earthquakes, but they should know that earthquakes are naturally occurring phenomena. Tell students that in this lesson, they will learn more about the ways the earthquakes can cause damage to infrastructure, and that they will have a chance to design a building that can survive a simulated earthquake.

**Grades K-1** Please note that the concept of earthquakes and geographical destruction may be distressing for some students, especially those in younger grades. If you suspect the concept may upset students, you should adopt a more sensitive approach to discussions and emphasize that earthquakes pose practically no direct danger towards people.

- 2.** Divide students into small teams and provide each student with the materials for the lesson, as shown below. Note that if you do not have freestanding tables, students will need a large piece of cardboard to help simulate earthquake conditions.



- 3.** Tell students that they will now design a structure using only the wooden blocks.

**Grades K-1** Before allowing students to design their own structure, model what the design process should look like for your students. Model a “think aloud” approach, and narrate your thoughts as you build a simple structure. For example, say, “I want to build a two-story building, so I’ll start with these large blocks on the bottom, then add these tall, narrow blocks for support. I’ll build my second story on top of these supports.” Then, encourage students to come up with their own design for a structure. Tell them it can be a building, a bridge, or any other structure they’ve seen in real life. A sample building is shown below. Students’ designs will likely be simpler than this image. Students should draw a quick sketch of their design on the Student Handout.

# STEPS FOR *SHAKY GROUND*

**Grades 2-3** Tell students to brainstorm some different types of buildings. They might say things like house, office building, skyscraper, bridge, and so on. Tell groups to pick one kind of structure and use the wooden block to build a model of this building. Circulate as they work to answer any questions or give model-building tips. A sample building is shown below. Students should draw a quick sketch of their design on the Student Handout.



4. Next, ask students to make a prediction about what will happen to their structures in the event of an earthquake. Most students should predict that their buildings or bridges will collapse.

**Grades K-1** Write several student predictions on the board.

**Grades 2-3** Instruct them to write their predictions in the space provided on the Student Handout.

5. Now, work with students to simulate a moderate earthquake.

**Grades K-1** Move from group to group and shake either the table or the piece of cardboard on which the structure is sitting. Instruct students to watch each structure as it shakes, then briefly discuss whether that group's prediction was correct or incorrect. Move among the groups, simulating an earthquake for each group.

**Grades 2-3** Instruct students to simulate a moderate earthquake. They should do this by gently shaking the table or the piece of cardboard on which the structure is standing. You may want to model the appropriate amount of shaking; in this way, all groups can attempt to simulate roughly the same magnitude earthquake. Tell students to carefully observe how their structure collapses: Does it topple inward? Does the bottom give out? Have students record their observations on the Student Handout.

6. Now, instruct students to modify their designs to make their structure stronger.

**Grade K-1** As before, model the appropriate building methods. For example, say, "When the earthquake hit, I noticed that the top blocks fell first, so I want to make sure they are secure. That's why I'm going to tape these short sticks to the blocks on the second story. That will make them more secure." Suggest ways that students can use the materials. You may opt to only allow younger students to use two or three of the

## STEPS FOR *SHAKY GROUND*

materials (rather than all of them), such as tape, Popsicle sticks, and straws. Give students time to work with their groups and make revisions to their designs, circulating as they work to offer design tips. Instruct students to build the same structure as before, but with reinforcements in place. A modified building with tape, glue, and braces, is shown in the image below.

**Grades 2-3** Allow students to use all of the available materials. Encourage them to discuss their designs within their teams and to search for innovative ways to make their structures stronger. You may wish to suggest some simple ways that they could reinforce their designs. Instruct students to build the same structure as before, but with reinforcements in place. A modified building with tape, glue, and braces is shown in the image below.

Your students' designs should all vary as there is no right answer to this problem. Allow for creative innovation, including securing the structure to the substrate. Have students quickly share their revised designs with the class before proceeding. Prompt students to explain the reasons for their modifications.



7. Follow the same instructions in Step 5 to simulate a moderate earthquake. This time, it's possible to have a range of results: Some structures may remain standing while others collapse. Some might suffer a minor amount of damage while others are completely ruined.
8. **Wrap-up Activity:** Once all groups have simulated two earthquakes, allow them to share their results with the class. Allow each group to share the highlights of their design, discussing what worked and what didn't work. Instruct older grades to answer the remaining questions on the Student Handout. Then bring the class back together as a large group and ask students several questions to get them thinking about the implications of this activity. Sample questions include:
- Why were some designs successful while others were not?
  - What do you think would happen if we simulated a more powerful earthquake?
  - Can you think of some other materials that could help make your design stronger?

# STEPS FOR *SHAKY GROUND*



## *Shaky Ground* Extension Activity

**Grades K-1** Show students the image from the Warm-up Activity of earthquake damage. Have them brainstorm ways that this damage could have been prevented with good design. Instruct students to create a drawing of their proposed solutions that would help prevent the earthquake damage shown in the image. Students can use the Extension Activity Handout to show their work.

**Grades 2-3** Challenge students to brainstorm other variables they could introduce into this activity. For example, different groups could build their structures on varying substrates. One group might build their structure on top of sand, another on clay, another on loosely packed soil. Repeat the investigation and have groups compare their results



## What is an earthquake?

An earthquake is the shaking of the Earth's surface, caused by movement beneath the surface. Earth's crust is made of many different plates, called tectonic plates. These plates slowly move. When two plates come into contact, one plate will move beneath or over the other plate. This causes pressure to build, and sometimes, the plates slip and pressure is released as an earthquake. Waves of energy then travel upward and are sometimes felt at the Earth's surface. Earthquakes can occur at varying depths and can have varying levels of strength.

## How can earthquakes damage structures?

Not all earthquakes are damaging. Some occur deep within Earth's crust and are not felt at the surface. Others occur at Earth's surface but are so weak that they do not cause substantial damage. Other earthquakes can occur in areas of sparse population, greatly reducing the damage. For an earthquake to be damaging, it must be of a large enough magnitude to cause structures to fail. The 2010 earthquake in Haiti caused great damage because it rippled through densely populated land on which many poorly constructed buildings and roads were built. Your students should know that many different factors can contribute to the harmful effects of earthquakes.

## How can engineering design help prevent or minimize earthquake damage?

There are several ways in which proper design and engineering can minimize earthquake damage. An important step is correct site selection. Some soils are prone to liquefaction, which is when the particles of the soil temporarily lose their strength and act more like a liquid during an earthquake. Engineers know to either avoid these soils or to drive supports into the bedrock so that structures can have solid foundations.

Engineers can also consider various aspects of the building design. One technique is to use diagonal bracing. Diagonal supports resist some earthquake waves and help the building stay in place. Shear walls, or walls with braced panels, are also used to resist compression, and help the structure stay intact as one piece. Engineering can also help structures survive surface waves. This is done through tie downs, which secure a building to its foundation. Tie downs also secure each level of the structure to each other, like frosting binds layers of a cake together. None of these techniques guarantees safety during a forceful earthquake, but they can help minimize the damage.

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## Key Vocabulary

**earthquake:** shaking of the ground as a result of movement within Earth's crust; can also be caused by volcanic activity

**seismic wave:** an elastic wave that travels through the earth as a result of an earthquake



1. Draw a picture of your design.

[Images will vary.]

2. Make a prediction about what will happen to your first structure (built with only wooden blocks) in a simulated earthquake.

I think my structure will fall down.

3. What did you observe about the way your structure collapsed in the first earthquake?

The wooden pieces slid back and forth for about a second before they collapsed. Most of the pieces seemed to collapse inward.

4. How did you change your structure after the first simulated earthquake?

We added a lot of support. We also glued the entire building onto our piece of cardboard.

5. Make another prediction about how your structure will fare after another earthquake.

I think the building will still move a bit, but I don't think any of it will fall down.

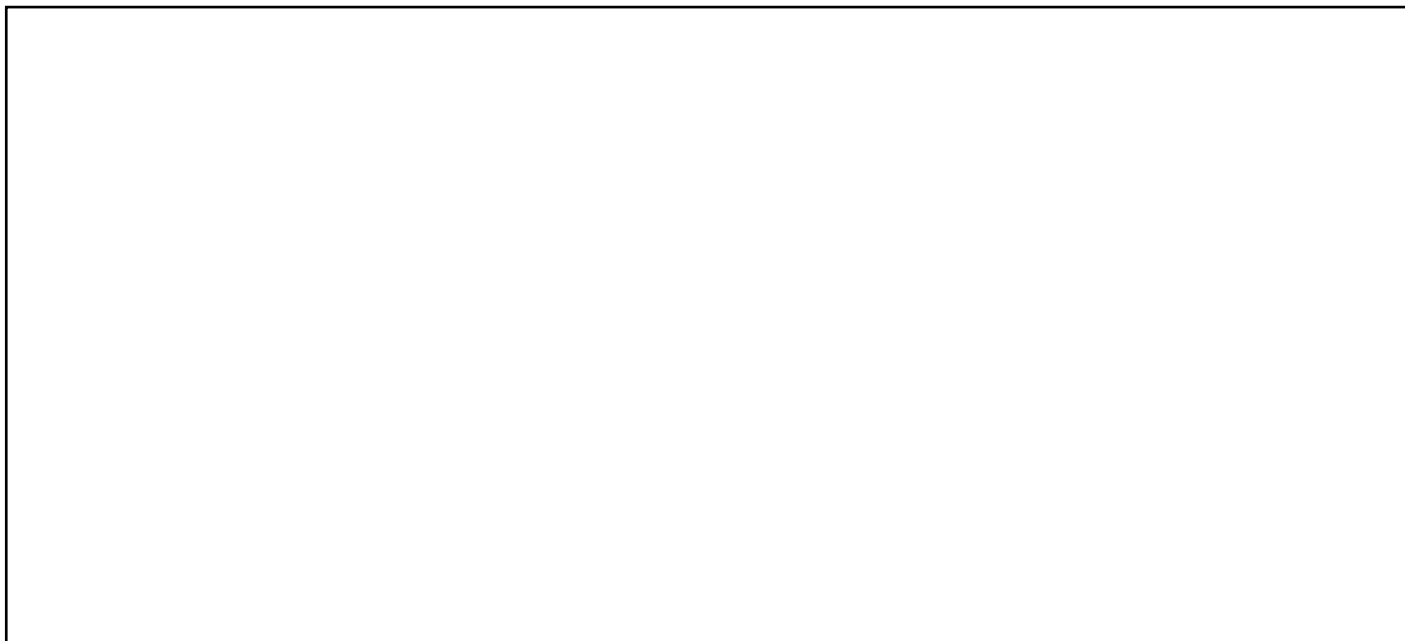
6. Why do you think it is important for buildings in real life to be designed to withstand earthquakes?

Good design can keep buildings from falling down in earthquakes. That can save people from dying in an earthquake.

Name:

Date:

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6. Why do you think it is important for buildings in real life to be designed to withstand earthquakes?

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Name:

Date:

How could the damage in the image have been prevented? Explain your answer.

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Illustrate your answer.

